Reg. No. :

J 3313

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2009.

Fifth Semester

Mechanical Engineering

ME 1303 — GAS DYNAMICS AND JET PROPULSION

(Regulation 2004)

Time : Three hours | Maximum : 100 marks

Use of approved Gas Tables is permitted.

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Draw the disturbances wave propagation in compressible flow for M = 1 and M>l.

2. When M* is used instead of M?

3. Draw the curve between A/A* and Mach Number M.

4. List the condition for choking in CD nozzle.

5. Write down the assumptions made in Rayleigh flow.

6. Give four examples of Fanno flow in thermal systems.

7. Write the Prandtl-Meyer relation for normal shock.

8. Write the change across normal shock for Mach Number and Static pressure.

9. What is after burning in turbojet engines?

10. Why rocket engines are called as non-breathing engine?

PART B — (5 × 16 = 80 marks)

11. (a) Air at rest at 90°C is accelerated isentropically (take $\gamma = 1.4$).

(i) What is the air speed in m/s when the Mach number becomes 0.8?

(ii) What is the air speed when the flow becomes sonic?

(iii) What is the Mach number when the air speed becomes 600 m/s. (16)

Or

(b) What is the effect of Mach number on compressibility? Prove for $\gamma = 1.4$

$$\frac{p_0 - p}{\frac{1}{2}\rho c^2} = 1 + \frac{1}{4}M^2 + \frac{1}{40}M^4 + \ldots \quad (16)$$

12. (a) Air is drawn isentropically from a standard atmosphere at sea level (101.3 kPa and 15°C) through a converging diverging nozzle. The static pressure at two different locations are 80 kPa and 40 kPa, respectively. Determine the Mach number at each of these locations. Also determine the velocity at each of these locations. (16)

Or

(b) A conical diffuser has entry and exit diameter of 150 mm and 300 mm respectively. The pressure, temperature, and air velocity at entry are 69 kPa, 67°C and 180 m/s respectively. Determine exit pressure, exit velocity and the force exerted on the diffuser walls. Assume isentropic flow. Take k = 1.4 and c_p = 1 kJ/kg.K. (16)

13. (a) Air flows with negligible friction in a constant area duct. At section one, the flow properties are t_1 = 60.4°C, p_1 = 135 kPa absolute and velocity 732 m/s. Heat is added to the flow between section one and section two, where the Mach number is 1.2. Determine the flow properties at section two, the heat transfer per unit mass and the entropy change. (16)

Or

(b) A circular duct passes 8.25 kg/s of air at an exit Mach number of 0.5. The entry pressure and temperature are 345 kPa and 311 K respectively. The average friction factor is 0.02 if the Mach number of entry is 0.15 determine,

(i) the diameter of the duct

(ii) length of the duct

(iii) pressure and temperature at the exit of the duct and

(iv) stagnation pressure loss. (16)

14. (a) A converging – diverging nozzle has an exit area to throat area ratio of 2. Air enters this nozzle with a stagnation pressure of 1000 kPa and a stagnation temperature of 360 K. The throat area is 500 mm^2. The divergent section of the nozzle acts as a supersonic nozzle. Assume that a normal shock stands at a point M = 1.5. Determine the exit plane of the nozzle, the static pressure, and temperature and Mach number. (16)

Or

(b) A convergent divergent nozzle operates at off design condition while conducting air from a high pressure tank to a large container. A normal shock occurs in the divergent part of the nozzle at a section where the cross section area is 18.75 cm^2. The stagnation pressure and stagnation temperature at the inlet of the nozzle are 0.21 Mpa and 36°C respectively. The throat area is 12.5 cm^2 and the exit area is 25 cm^2. Estimate the exit Mach number, exit pressure. Loss in stagnation pressure and entropy increase during the flow between the tanks. (16)

15. (a) Describe the working of supersonic ramjet engine with a neat sketch. List out its advantages and disadvantages. (16)

Or

(b) (i) Explain the principle of operation of liquid propellant and solid propellant engines with neat sketches. (10)

(ii) List down the advantages of liquid propellant rockets. (6)
